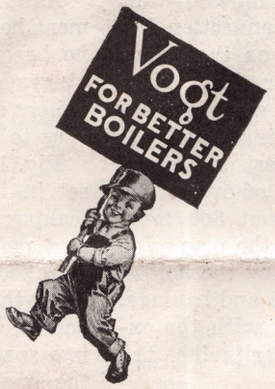
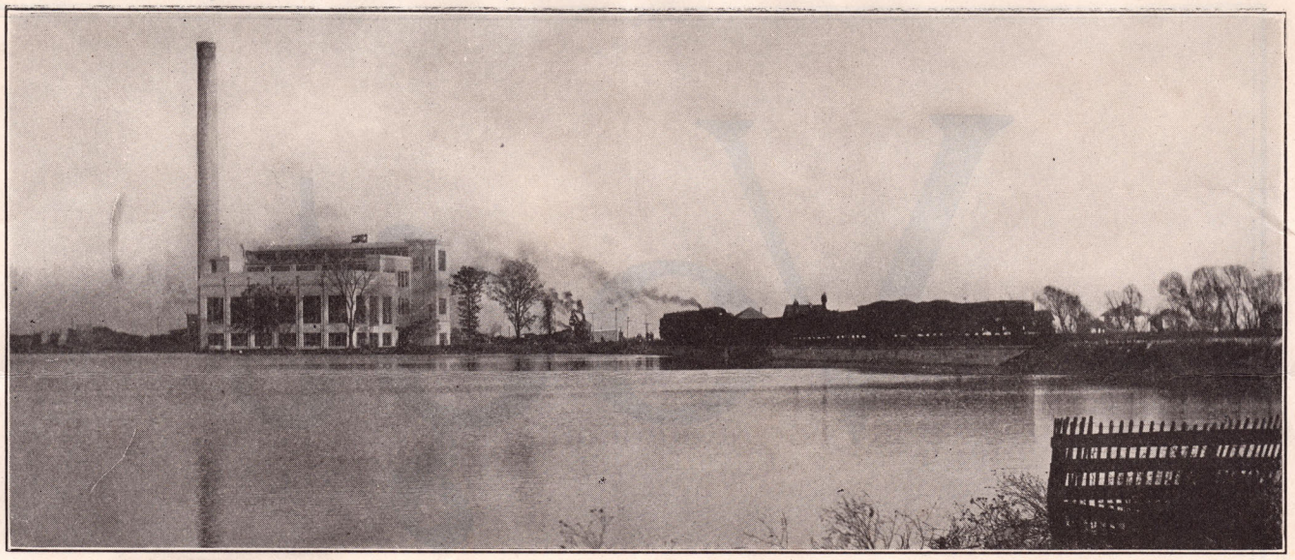
Vogt

Water Tube Boilers

The installation in the Standard Oil Mine Plant at Schoper



Reprinted from
POWER
Issue of August 30, 1921



Standard Oil Mine Plant at Schoper

A 6,250-kw., three-unit plant serving electrically three coal mines featured by forced-draft chain grates in the boiler room, use of concrete in the settings and a waste-heat superheater at the rear of the boiler. Coal is dumped from railway cars into the overhead bunker and the same type of car receives the ash at grade.

THE DIFFICULTY of securing coal of the desired quality and in sufficient quantity during the industrial expansion resulting from the late war, led the Standard Oil Co., of Indiana, to secure coal mines of its own for supplying its various refineries and as a source of power for operating these mines to erect a modern power plant. An established mine in the town of Carlinville, Ill., having an output of about 400 tons per day was purchased. Its capacity was enlarged to a daily run of 1,200 tons and 1½ miles distant another shaft was sunk with a tunnel connection between the two. From the latter, known as the Berry mine, 2,500 tons may be turned out per day. Nine miles away at Schoper the coal rights on certain properties were purchased and a mine is being developed that eventually will be one of the largest and most modern in the state requiring the services of over 1,000 men. At present the daily output is about 800 tons. To secure greater flexibility and economy, the new mine is electrically operated throughout, including the hoists, mining machinery, air compressors, pumps and haulage. The same is true of the other two mines, with the exception that in the older mine under Carlinville, the steam hoist has been retained.

About one-half mile from the new Schoper mine is the site of the power house. It has a capacity of 6,250 kw. in three units, generating current at 6,600 volts, three-phase, 60 cycles, and is served by four boilers, each having 5,000 sq.ft. of steam making surface, an allowance of 3.2 per sq.ft. of heating surface per kilowatt of generator rating. The importance of economy in the plant as well as in the mines, was fully realized, so that in the selection and layout of the power-plant equipment, economy was the primary factor. To handle successfully the variable loads common to coal mines, where the demand may vary rapidly in the ratio of one to three, forced-draft chain grates were installed under the boilers, and in the latter superheaters were installed at the rear of the settings to recover as much waste heat as possible from the flue gases. Other features of interest are the use of concrete in the boiler settings, the water supply from an artificial lake and the simple direct methods of handling coal and ash.

Reference to the headpiece will show that the power-plant building is of reinforced concrete after the style of architecture generally adopted by the Standard Oil Co. The company has been liberal in providing for the comforts of the employees. Shower baths, lockers, toilets and other facilities are available and homes for the operating force have been constructed in proximity to the plant, which are of modern design, with bath, toilet, electric lights and furnace.

As it was not desirable to place the condensing equipment below the level of the artificial lake, the plant has no basement, the condenser auxiliaries being installed at grade level and the main generating units and the boilers on the second floor, thus giving the height necessary to dispose of the ash directly into railway cars.

Fig. 1 is a view of the boiler room showing four units set individually, each containing 5,000 sq.ft. of steam-making surface. There is space in the boiler room for two more units of the same capacity, which will be installed as soon as needed. Reference to Fig. 2 will show that the boilers are horizontally baffled for three passes, and between the boiler proper and the rear wall is a space down which the outgoing gases are drawn to the smoke flue. This flue passes underneath the boiler-room floor to a concrete stack exterior to the building, which is 12 ft. in diameter at the top and rises 213 ft. above the foundation.

In the space at the rear of each boiler is located a waste-heat superheater, designed by A. P. McCormick, chief engineer of the Wood River plant of the company. This superheater receives the steam from the boiler at 170 lb. pressure and at 200 per cent of rating will superheat it about 100 deg., utilizing heat

that would otherwise be wasted. The superheater consists of two drums suspended vertically, between which 290 two-inch tubes pass horizontally across the boiler setting. As shown in Fig. 3, the steam enters at the bottom of one of the drums and by means of interior baffling, is made to pass back and forth four times through the tubes before it escapes at the top of the drum into the main steam header. In the tube ends are placed cast-iron reducing plugs, as indicated in Fig. 3, in line with the flow of the steam to insure equal distribution throughout the entire surface of the superheater. The form of this plug is indicated in the drawing.

From each superheater an 8-in. pipe leads to the main steam header, of 12 in. diameter, located back of the boilers. Drop pipes of the same diameter at either end connect with a delivery header underneath the boiler-room floor, thus forming a vertical ring header with four sectionalizing valves, from the lower run of which 5-and 8-in. supply pipes lead to the turbines and a 3-in. lead to the auxiliaries.

In the plan view, Fig. 2, is shown the construction of the setting walls. The side walls are made of 9 in. of firebrick, 4 in. of insulating brick and on the exterior 9 in. of concrete, with the firebrick bonding into the concrete wall as indicated. In the rear wall the insulation is omitted, there being 9 in. of firebrick and 10 in. of concrete. The concrete was used merely as a covering, as it had given good service for the same purpose at the Wood River plant of the company. It is not exposed to severe temperature and the hand may be placed on it without any discomfort. The boilers have been in operation for over a year and with the exception of a little surface cracking, there are no defects in the concrete boiler walls. The boiler setting is suitably braced and the boiler itself is suspended from steel work as indicated in the drawing. This same illustration, Fig. 2, shows that the lower, front drum header is set 12 ft. above the floor, giving the comparatively large furnace volume necessary for high rates of combustion.

As a coal mine load is variable and it was estimated in this particular case that it would have a range of 3 to 1 at intervals throughout the day, it was desired to install a stoker equipment flexible enough to meet these peaks with the units that might be in operation, rather than carrying continuous extra boilers on the line to help out at maximum load. To burn Southern Illinois coal chain grates were desirable and the forced-draft was selected to obtain the flexibility desired. It was anticipated that operation on this order would increase considerably the overall economy of the plant, as the coal that would otherwise be required to carry extra boilers would be saved, and the combustion effi-

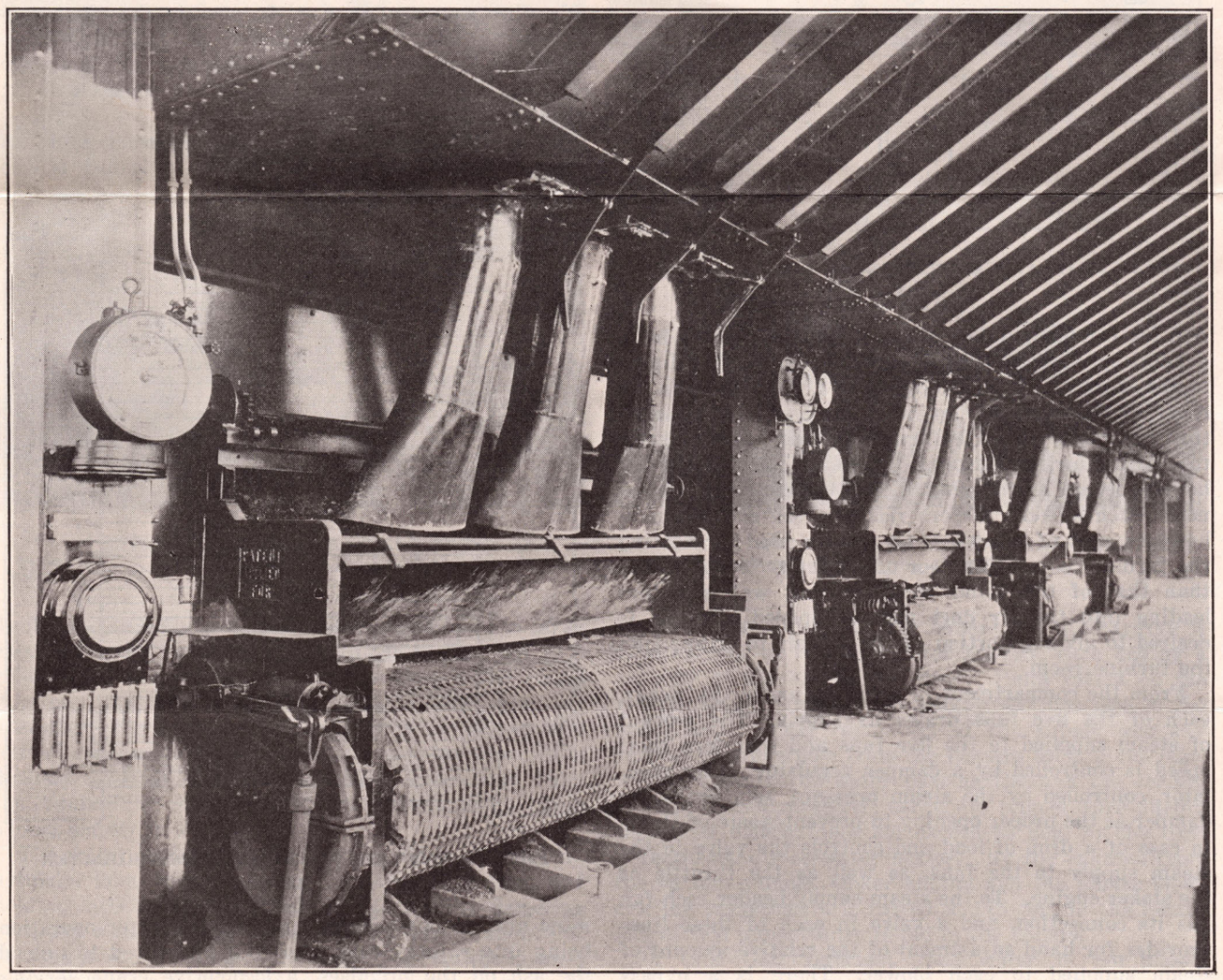


FIG. 1. PRESENT BOILER EQUIPMENT SERVED BY FORCED-DRAFT CHAIN GRATES

ciency would be higher by supplying air more nearly in the proper proportions to the various sections of the grate.

Each stoker is 10 ft. wide by 12 ft. long, giving an active grate surface of 120 sq.ft. which to the steam-making surface bears a ratio of 1 to 41.7. The stoker has five zones with an individual blower for each zone.

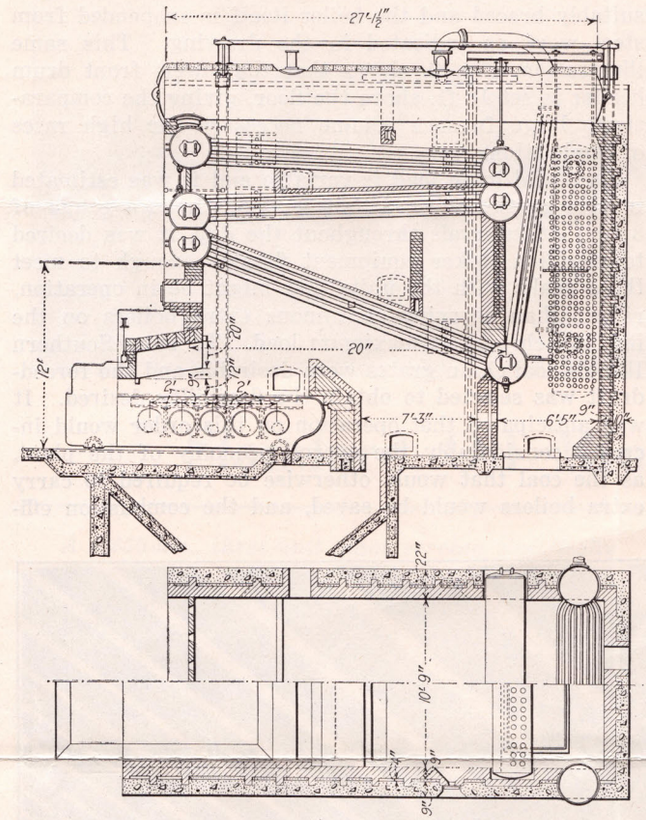


FIG. 2. PLAN AND ELEVATION OF BOILER SETTING

Air for combustion is first used for cooling the main generating units. By the generator fan it is drawn to the machine from the outside or from the turbine room as the seasons may warrant, and is discharged through ducts which to farther increase the temperature of the air, pass around the main smoke flue of the boilers before discharging into a compartment underneath each stoker. Before reaching the compartment, however, part of this warm air may be used for heating the turbine room. The floor of the latter is 5 ft. lower than that of the boiler room, so that wall registers leading into the air duct may be opened when it is desired to allow a portion of the hot air to escape into the turbine room.

From the compartment or chamber under the stoker, each of the five fans draws its supply. The amount of steam supplied to the five fans and therefore their speed is controlled by a damper regulator. This regulator, controlled by the steam pressure, sets the boiler damper at the proper opening to prevent waste of steam in case of a drop of load and controls the valve in the steam supply to the fans, as well as the throttle of the stoker engine. To the steam supply header each fan has its connection, and a valve in each of these lines provides for hand adjustment of the relative amount of steam supplied to each blower. There is a bypass around the regulating valve on the supply header, which is used principally when starting up. Siftings that may collect in each one are blown into a compartment at the side of the settings, opening downward into a hopper from which the fuel may be discharged into railway cars and returned to the overhead bunker. The hopper is located at the side of the ash hopper which is built of reinforced concrete and likewise is arranged to discharge into railway cars through gates operated by air cylinders.

Power to drive the stokers is supplied by two vertical engines located on the first floor, which are belted to a line shaft suspended from the boiler-room floor. Provision is made also to drive the line shaft by a motor used ordinarily in the machine shop. The line shaft is belted to an individual jack shaft serving each stoker, having loose and tight pulleys and an eccentric for driving the stoker.

To give the data necessary for efficient operation, each boiler has its individual instrument board mounted on a steel column supporting the bunker and located at the boiler front between the settings. As indicated in Fig. 4 there is a pressure gage for each boiler, a steam flow meter to record the output, a differential draft gage with connections over the fire and at the outlet, a recording pyrometer to take the flue temperature and U-tube draft gages to indicate the pressure in each zone. CO_2 readings are taken with an orsat.

Operation of the plant is so nearly automatic that only nine men are required to operate the plant continuously. They are distributed as follows: Three engineers, consisting of the chief engineer and two running engineers; three firemen, one on each shift; an oiler and two men of general work.

As a typical example, it is not necessary to touch the coal by hand from the time it is loaded at the mine until it is discharged as ash, the latter operation being into railway cars, and if it is desired to unload the ash on the premises, a locomotive crane serving both the plant and the mine is available for the purpose.

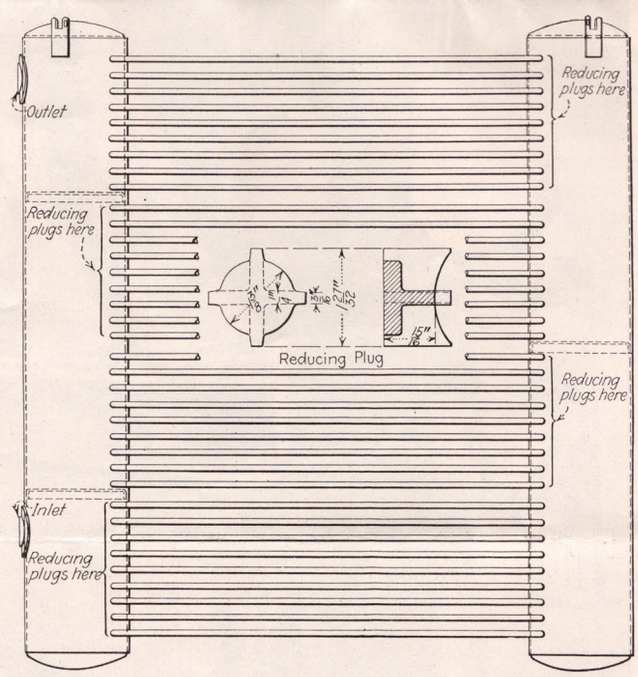
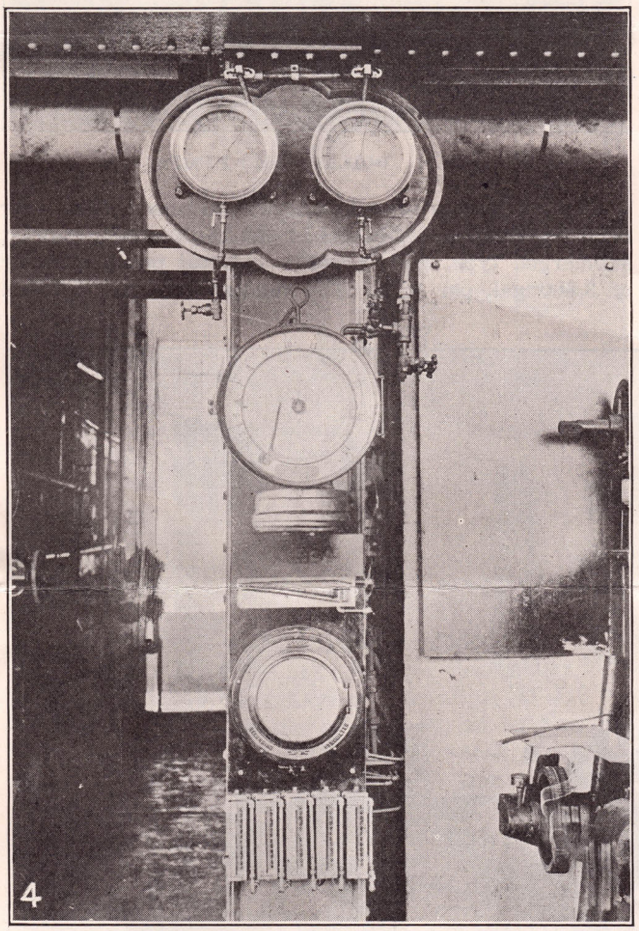


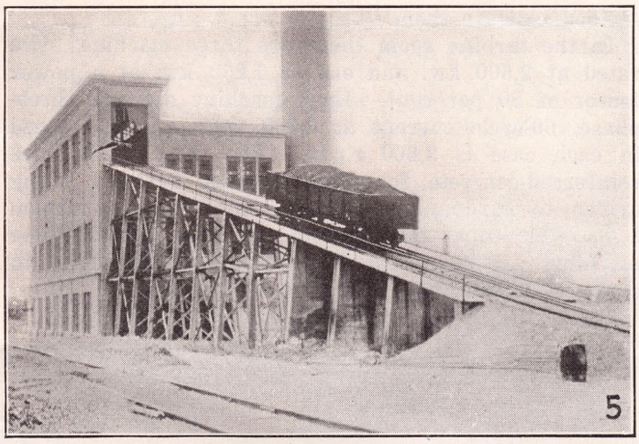
FIG. 3. TUBULAR WASTE-HEAT SUPERHEATER

The coal for power plant use is crushed at the mine and is conveyed to the station in standard railway cars pulled by an electric locomotive owned by the company. At the plant these cars are pulled up an inclined trestle with a grade of 20 per cent to an elevation above the overhead 800-ton steel bunker serving the four boilers. See Fig. 5. The motive power in this case is supplied by a 50-hp slip ring induction motor geared to a hoisting drum. A safety device, commonly known as a "goat," is coupled to the rear of the car and follows it up to prevent accident in case the hoisting cable should break. The railway track continues over the bunker top and from bottom dump cars the coal is discharged directly into the bunker. The hoist is large enough to take two 50-ton cars up the incline, but as a rule only one car is pulled up at a time. The round trip requires about 30 min., so that with one car operation, the equipment has capacity to deliver 100 tons of coal per hour, and with two cars the capacity is doubled. Triple spouts with sliding gates lead from the bunkers to each stoker, the arrangement being shown plainly in Fig. 1.

The water supply for the plant is obtained from an artificial lake, covering about 35 acres of ground and holding 90,000,000 gal., which was formed by damming up a wet weather creek. The concrete dam is about 600 ft: long and 18 ft. high at the center. From the deepest point at the center of the dam a flume leads to two cold wells under the condenser floor, one for supplying water to the condensers and the other to supply boiler feed water. From the cold well the feed water is forced through four cast-iron cooling sections placed two on either side in the furnace walls to prevent clinker adhering to the brickwork and through a water back at the rear of the furnace. These four sections, each 8 in. square, and the water back are connected in multiple to the supply header through ¾-in. lines, so that if one section becomes clogged or out of service in some way, the others will continue to function. The water enters at the bottom and discharges at the top of the section, the various outlets being connected to a 3-in. line which in turn delivers to a 6-in. main receiving the water from the four boilers and discharging it to either one of two feed-water heaters, each having a capacity of 250,000 lb. per hour. Hand valves on the various supply lines to the cooling sections and to the water back permit regulation of the supply and any surplus may overflow from the heaters back to the lake. As the quantity of water passing through the cooling sections is comparatively large, its temperature during the colder months does not exceed 84 deg. by the time it reaches the feed-water heater. By the exhaust from the various pumps, stoker engine and the stoker blowers, the temperature is raised to 175 deg. in the heater and at this temperature is fed to the boilers.

In case that sufficient feed water is not passed through the furnace cooling sections, a provision has been made to automatically supply the deficiency. Any





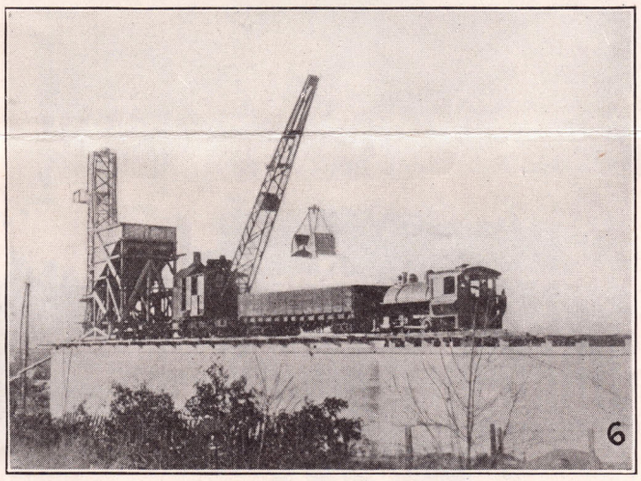


FIG. 4. INDIVIDUAL BOILER INSTRUMENT PANEL. FIG. 5. COAL CAR PULLED UP INCLINE TO OVERHEAD BUNKER. FIG. 6. BUILDING CONCRETE DAM TO FORM ARTIFICIAL LAKE

one of three auxiliary make-up pumps with suction connection to the cold well, are kept under steam pressure and may be started or stopped by the pump governor under the control of an automatic float valve in the heater. At present a surplus of water is available, but as the load increases there may be need for the auxiliary pumps mentioned. The two heaters are located on a platform between the first and second floors, so that they may supply the boiler feed pumps under head. Of the latter there are three of the reciprocating type which discharge to the boiler under hand control. An 8-in. feed main and an auxiliary 6-in. line for feeding or washing have been provided. The pumps are connected to both mains and their services may be divided between them.

In the turbine room there are three machines, two rated at 2,500 kw. and one at 1,250 kw. at a power factor of 80 per cent. Each machine delivers three-phase, 60-cycle current at 6,600 volts and the speed in each case is 3,600 r.p.m. The three units have reinforced-concrete foundations which rest on piling driven to hardpan. Spacing around the foundation 1 in. wide separates it from the floor, so that the machines are isolated and there is no opportunity to transmit vibration to building construction.

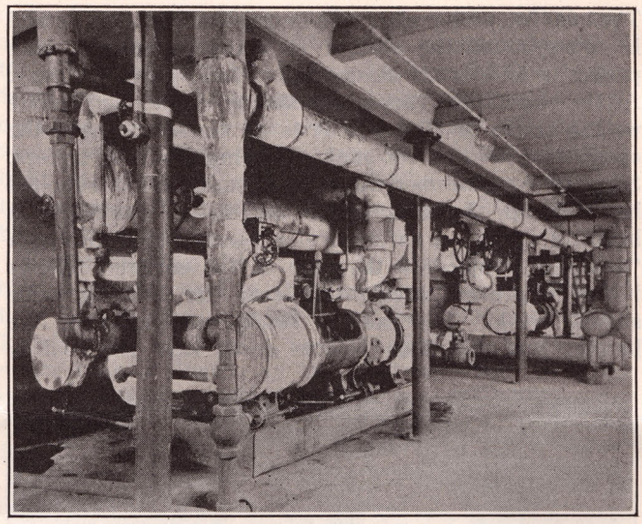


FIG. 7. BOILER-FEED PUMPS

Each turbine is served by a jet condenser, the larger machines having condensers of the 16-in. double-runner, submerged type, with a water removal pump capacity of 3,800 gal. per min. The smaller unit has a 12-in.

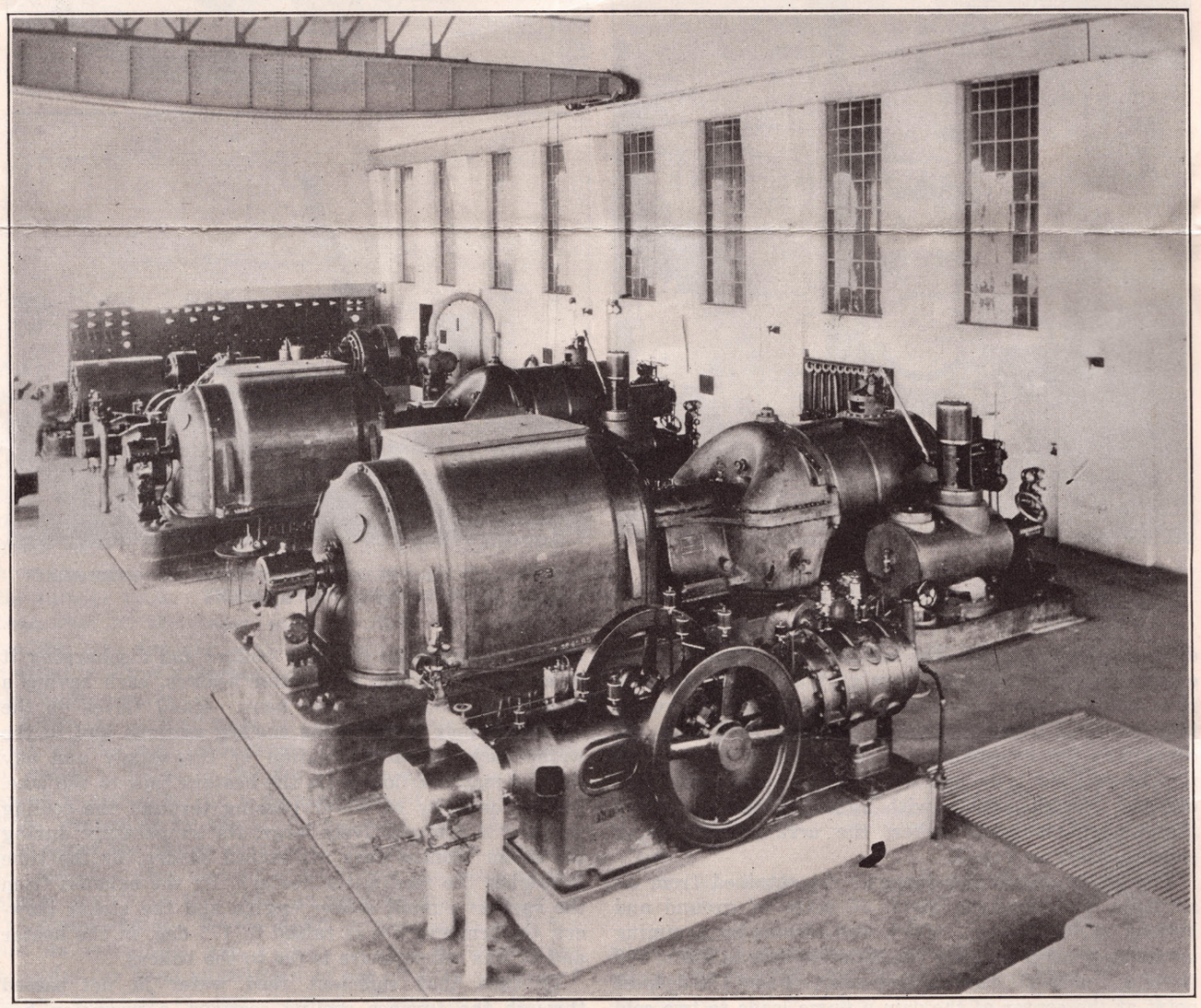


FIG. 8. PRESENT EQUIPMENT OF TURBINE ROOM

single-runner jet condenser with a pump capacity of 1,900 gal. per min. The dry vacuum pumps, which are of the reciprocating type, are located on the turbine-room flood.

For the most part the electrical load is made up of induction motors, the large motors driving the hoists and the ventilating fans are of the slip-ring induction

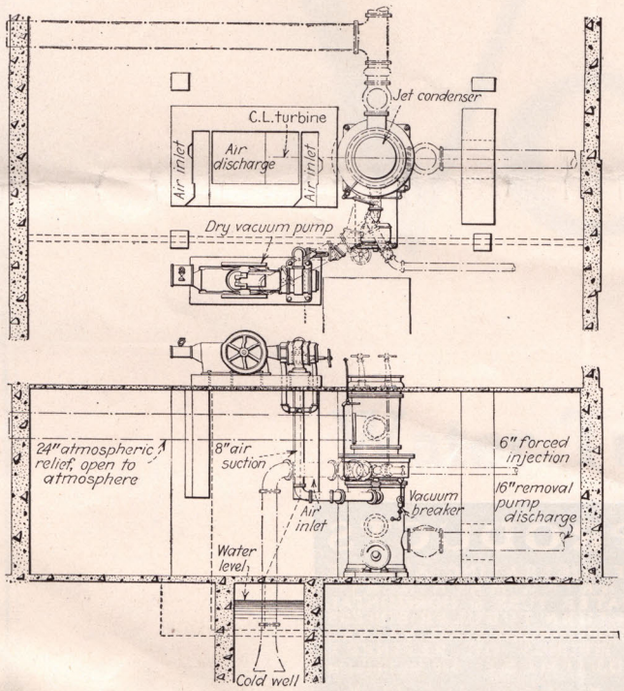


FIG. 9. PLAN AND ELEVATION SHOWING LAYOUT OF CONDENSER AND AUXILIARIES

type with liquid rheostat control. These larger motors are designed for 2,200 volts, but for the smaller motors and for lighting the voltage is reduced to 220-110 volts. To offset the lag in the current caused by the induction motor load, a number of synchronous motors have been installed, principally in connection with motor-generator sets at the mines supplying direct current for charging the batteries and for mine haulage. Under normal conditions a power factor of 90 per cent is obtained, and when charging the batteries, the power factor runs up to unity.

To the Schoper mine, current is transmitted at generator voltage and at the mine is stepped down to 2,200 volts for the motors driving the hoists and the ventilating fans. In a substation down in the mine, the 2,200 volts is reduced to 220 through a synchronous motor-generator set to supply the direct current needed. For transmission to the Berry and Carlinville mines, 9 miles distant, the voltage is stepped up to 33,000 and at the receiving end is stepped down to 2,200 volts for the large motors and to 220 volts direct current for the other services, as mentioned.

Excitation is supplied by four exciter sets, two of 15-kw. capacity and two rated at 75 kw., one of each pair being steam driven and the other directly connected to an induction motor. The motor-generator sets are used when the plant is in operation and the steam sets for starting up.

A switchboard of standard construction and equipment has been placed at the end of the turbine room.

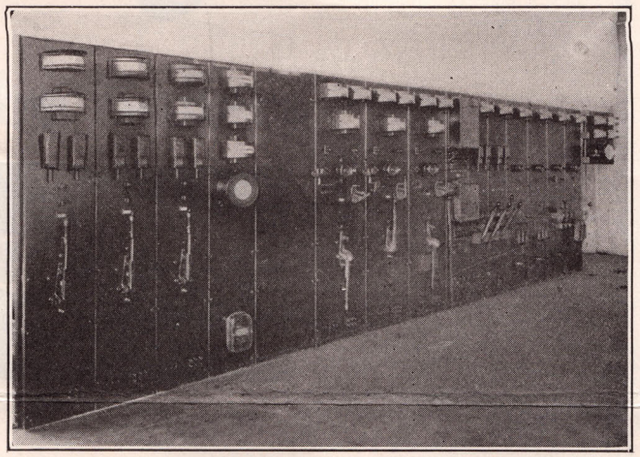


FIG. 10. MAIN SWITCHBOARD OF PLANT

The oil switches, buses and transformers are located on the floor below and at the same level is a standard outdoor substation serving the Berry transmission line.

A. P. McCormick, chief engineer at the Wood River plant, is responsible for the design of the power station under description. The operation of the plant is under the supervision of C. W. Clark, who is assistant manager of the mining property.

PRINCIPAL EQUIPMENT OF STANDARD OIL PLANT AT SCHOPER, ILL.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Water-tube	5,000 sq.ft.	Generate steam	170 lb., 100 deg., superheat, forced draft	Henry Vogt Machine Co.
4	Superheaters	Tubular		Serve boilers	Located in last pass	A. P. McCormick
4	Stokers	Forced-draft ch. grate	120 sq.ft.	Serve boilers	Five zone, five blowers	Illinois Stoker Co.
2	Engines	Vertical	6x6-in.	Drive stokers	Under control of damper regulator	American Blower Co.
2	Pumps	Reciprocating	10x16x8½x10 in.	Boiler feed		Worthington Pump & Mach. Corp.
1	Pump	Reciprocating	14x8½x10 in.	Boiler feed		Worthington Pump & Mach. Corp.
3	Pumps	Reciprocating	6x9x7x10 in.	Auxiliary make-up		Worthington Pump & Mach. Corp.
1	Pump	Reciprocating	12x18x14x12 in.	Service		Worthington Pump & Mach. Corp.
1	Pump	Reciprocating	14x14x12 in.	Service		Worthington Pump & Mach. Corp.
2	Heaters	Open	250,000 lb. per hr.	Heat feed water	Exhaust steam, water 84 to 175 deg.	Harrison Safety Boiler Works
1	Hoist	Electric	200 tons per hr.	Pull Ry. cars over bunker	Geared to G. E., 50-hp. ind. motor	Lidgerwood Mfg. Co.
2	Turbines	Parsons	2,500 kw.	Main generating unit	160 lb. steam, 100 deg., superheat, 3,600 r.p.m.	Allis-Chalmers Co.
2	Generators	A. C.	2,500 kw.	Main generating units	6,600 volts, 3-phase, 60-cycle, 3,600 r.p.m.	Allis-Chalmers Co.
1	Turbine	Parsons	1,250 kw.	Main generating unit	160 lb. steam, 100 deg. superheat, 3,600 r.p.m	Allis-Chalmers Co.
1	Generator	A. C.	1,250 kw.	Main generating unit	6,600 volts, 3-phase, 60 cycles, 3,600 r.p.m.	Allis-Chalmers Co.
2	Condensers	Jet	16-in. dble runner	Serve 2,500 kw. turbines	Dr. by 85-hp. Ind. motor, 1,160 r.p.m.	Allis-Chalmers Co.
1	Condenser	Jet	12-in. sgl. runner.	Serve 1,250-kw. turbine	Dr. by 40-hp. Ind. motor, 1,160 r.p.m.	Allis-Chalmers Co.
2	Air pumps	Dry	8x18x12 in.	Serve condensers 2,500 kw. unit		Allis-Chalmers Co.
1	Air pump	Dry	6x15x10 in.	Serve condenser, 1,250 kw. units		Allis-Chalmers Co.
2	Exciters		75-kw.	Excitation main units	One driven by 12x13 in. Ideal eng.; one ind. motor-driven	Allis-Chalmers Co.
2	Exciters		15-kw.	Excitation main units	One dr. by A.B.C. 7x7 in. engine; one ind. motor driven	Allis-Chalmers Co.
3	Transformers	Oil-cooled	150 k.v.a.	Power to large plant motor	6,600-2,200 volts	General Electric Co.
1	Crane	Hand-operated	20-ton	Serve turbine room		Whiting Fdry. Equipment Co.

Coppus blowers for stokers; Defender damper regulators; Defender differential draft gages; Defender U-tube draft gages; G.E. flow meters; Hoskins recording pyrometers; Marsh pressure gages; McMyler locomotive crane, 2-ton bucket; Bayers soot blowers; Foster automatic stop and non-return valves; Crane steam and water valves; Everlasting blow-off valves; Crosby safety valves, Allis-Chalmers switchboard with Wagner and Westinghouse meters and G.E. circuit breakers.

Vogt

PRODUCTS

REFRIGERATING AND ICE MAKING MACHINERY—WATER TUBE & HORIZONTAL RETURN TUBULAR BOILERS DROP FORGED STEEL VALVES & FITTINGS—OIL REFINERY EQUIPMENT—*Ask for Bulletins*

HENRY VOGT MACHINE CO., Manufacturers, Louisville, Ky.